The Effect of Land Use on Stream Water Phosphorus Concentrations in the Lake Champlain Watershed

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Introduction

In recent decades the health of Lake Champlain and other bodies of water within its basin have come in to question, resulting in increased scientific inquiry (Lake Champlain Basin Program, 2012). Studies have had a wide range of foci, particularly the possible causes for the rapid maturation of sections of the lake. This research has indicated a correlation between the phosphorus levels and the stage of eutrophication in Lake Champlain. Finding elevated levels of phosphorus in various sections of the lake has scientists and citizens concerned about the threats posed by premature eutrophication. These concerns have lead to increased monitoring of the lake along with its surrounding waters, and stressed the need to find the causes of the high levels of phosphorus. The purpose of this study was to investigate the relationship between various land uses and stream Total Phosphorus levels at selected locations in streams of the Lake Champlain watershed.

Methods

Stream flows in Dowsville Brook were assessed through use of a pressure sensing meter via a Hobo Water Level Logger; range 0 to 9 m, P/N: U20-001-01 S/N:10137324. Air pressure was measured using a Hobo Water Level Logger; range 0 to 9 m, P/N: U20-001-01 S/N:10137324. The stage sensor was fixed into place in Dowsville Brook utilizing a specially constructed apparatus composed of plastic pipe, mounted on a steel rod (Figure 1). It was mounted in the stream in July, 2012 and left in place until late October, 2012. The stage sensor was removed just prior to Hurricane Sandy in an effort to save the probe from being washed away. The two probes allowed the absolute pressure difference in the water column to be determined. The pressure differences were converted to a water elevation, which allowed the water elevation to be monitored continuously. The data from the pressure probes were downloaded, via a HOBO Waterproof Data Shuttle, approximately every two to four weeks and downloaded to the computer.

Each time the pressure data were downloaded, water chemistry samples were also collected for Total Phosphorus and Total Suspended Solids analyses. Samples were analyzed by the Streams and Environmental Toxicology Lab at Johnson State College, Johnson, Vermont. For the Total Phosphorus determination, the Persulfate Digestion and the Ascorbic Acid Method were followed, as described in *Standard Methods for the Examination of Water and Wastewater* (APHA, 1992). Teams of investigators around the state of Vermont followed the same procedures. The water chemistry test results were published via the internet so other investigators Vt EPSCoR Research on Adaptation to Climate Change (RACC) could also make use of the data. The data is available at http://www.uvm.edu/~streams/index.php?Content=pages/download_data.inc.

Data from the RACC group were used to investigate the relationship between land uses (forested, urban, and agricultural) and average stream Total Phosphorus levels. Data from ten (10) sites in the Lake Champlain watershed were used. They were the Dowsville Brook, Potash Brook, Pond Brook Colchester, Huntington River, Englesby Brook, Black Creek, Snipe Island, Stone Bridge Brook and Little River sites. A listing of the latitude and longitude of the sites is shown in Table 1.

Figure 1. Stream Stage Sensor Apparatus_

Table 1
Site Locations

Site code	Stream Name	Stream Site Watershed	Latitude	Longitude	School	Teacher
WR_DwllBrk_649	Dowsville Brook	Winooski	44.24627	-72.78064	Harwood Union High School	Jeff Robins
LCD_PndBrk_179	Pond Brook	Lake Champlain Direct	44.55656	-73.153308	Colchester High School	Kara Lenorovitz
WR_HntRv_536	Huntington River	Winooski	44.35026	-72.99118	Vermont Commons School	Peter Goff
LCD_PoBrk_133	Potash Brook	Lake Champlain Direct	44.44663	-73.20401	Rice Memorial High School	Sharon Boardman
WR_GoldBrk_952	Gold Brook	Winooski	44.445258	-72.667987	Stowe High School	Don McDowell
WR_LtlRiv_696	Little River	Winooski	44.46964	-72.68195	People's Academy	Sheila Tymon
MR_BlckCrk_400	Black Creek	Missisquoi	44.76453	-72.85233	Bellows Free Acad. Fairfax	Thomas Lane
LCD_StnBrBrk_133	Stone Bridge Brook	Lake Champlain Direct	44.677301	-73.205625	Milton High School	Lynn Fosher
WR_SIBrk_711	Snipe Island Brook	Winooski	44.42312	-72.94413	Rock Point School	Kathy Rossman
LCD_EngBrk_117	Englesby Brook	Lake Champlain Direct	44.456134	-73.213635	Rock Point School	Kathy Rossman

Graphs

Figure 2. Stage Sensor Depth In Dowsville Brook (feet)

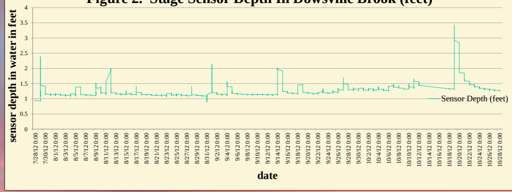


Figure 3. Effect of Fraction Forest Cover on Phosphorus in Surface Water

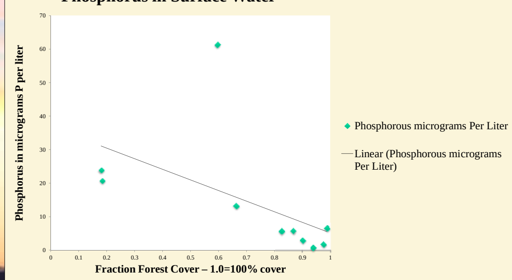


Figure 4. Effect of Urban Land Use Percent Cover on Phosphorus in Surface Water

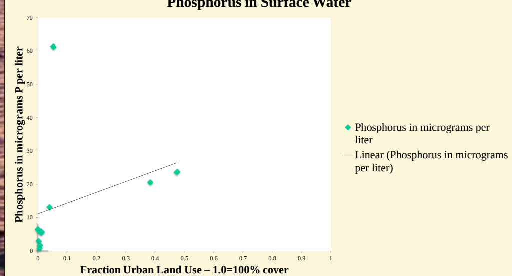
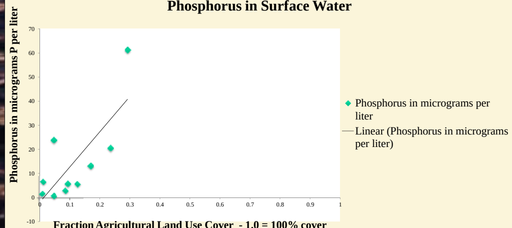


Figure 5. Effect of Fraction Agricultural Land Use Cover on Phosphorus in Surface Water



Results, Data Analysis, and Discussion

The stage sensor results are summarized in Figure 2. The data provide baseline information for the flow in Dowsville Brook. The data show a general rise in the stream level of approximately 0.2 feet following the leaf fall of late September/early October, when photosynthesis and evapotranspiration decreased in the watershed. Storm events can be seen as short-term spikes in the water level of the Dowsville Brook. The data will be helpful in assessing hydrological impacts of future development in the Dowsville Brook watershed.

Figures 3, 4, and 5 are graphs that utilize pooled data from the internet shared by other investigators on the project. Average values for Total Phosphorus samples, collected during the 2012 sampling season, were calculated for 10 sites: Dowsville Brook, Potash Brook, Pond Brook Colchester, Huntington River, Englesby Brook, Black Creek, Snipe Island, Stone Bridge Brook and the Little River. Statistical analyses to determine linear regression statistics were carried out via Stat Plus:Mac software.

Figure 3 is a graph of the fraction forest cover versus average Total Phosphorus concentration in stream water from selected sites in the Lake Champlain watershed. The least squares linear regression best fit line is not statistically significant (p=0.11531, R squared = 0. 28). Qualitatively, a relationship appeared to exist but it was not confirmed. More data from more sites might provide more evidence for or against the relationship. Visually on the graph there appeared to be a direct relationship that the greater the fraction forest cover in the watershed, the lower the Total Phosphorus concentration.

Figure 4 is a graph of the fraction urban cover versus average Total Phosphorus concentration in stream water from selected sites in the Lake Champlain watershed. The least squares linear regression best fit line is not statistically significant (p=0.31105, R squared = 0. 3168). Qualitatively, a relationship appeared to exist but it was not confirmed. More data from more sites might provide more evidence for or against the relationship. Visually on the graph there appeared to be a direct relationship that the greater the fraction urban cover in the watershed, the higher the Total Phosphorus concentration.

Figure 5 is a graph of the fraction agricultural cover versus average Total Phosphorus concentration in stream water from selected sites in the Lake Champlain watershed. The least squares linear regression best fit line is statistically significant (p=0.0109, R squared =0. 5761). The greater the fraction agricultural land cover in the watershed, the higher the Total Phosphorus concentration.

References

- Lake Champlain Basin Program, State of the Lake 2012. www.lcbp.org/PDFs/SOL2012-web.pdf
- Liu, Sylvia. Background sunset photo from http://www.sylvialiuland.com/2012/08/lake-champlain-sunset.html © 2012 Sylvia Liu with permission from Sylvia Liu
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